PROOF

FILTRATION

......BY......

P. A. MAIGNEN

MAIGNEN'S
FILTRATION COMPANY
1310 Arch Street
PHILADELPHIA

FILTRATION.—Filtration is generally defined as the process by which liquids are separated from substances mechanically suspended in them.

In the arts, filters have been used from time immemorial; the oldest filtering device known was made of felt.. It is called in households "Jelly Bag," and among liquor dealers and druggists "Filter Bag," and Hippocrates' Sleeve.

The word "filter" itself is etymologically traced in almost every language to the word "felt," *i. e.*, fulled wool. It is rendered in Anglo-Saxon, "felt;" in Swedish, "filt;" French, "filtre;" Italian, "feltro," and Latin, "filtrum" or "feltrum."

This invention, if we may call it so, has stood the test of very many centuries, and it has seemed to us worthy of investigation.

Filtration through felt is not a sieving action, but a capillary action.

In sieves made of silk, horse hair or wire gauze, the passages are fixed pores, the threads used to make the sieves have in themselves no filtering quality; when the meshes of the sieves are open, those particles which are smaller than them pass with the water, and when the meshes are choked nothing goes through.

In felt, on the contrary, there are no meshes, there are no fixed pores, the fibres are interlaced and lying so close to one another that liquids can only pass by capillarity, as is the case with lamp wicks.

In felt or felted cloth the whole surface is effective; the speed of filtration is not due to large passages, but to their great number. It is therefore evident that the best and most rapid filtration of water ought to be obtained with felt.

Twenty years ago we started to filter water through felt, but we were thwarted and soon vanquished.

We tried every sort and quality of felt; after a very few days in water, the felt itself underwent putrid decomposition, and had to be given up.

Wool is organic matter; when in water, it soon becomes an easy prey to the busy microbes, and goes the way of all members of organic bodies cut off from the living trunk.

ASBESTOS FELT.—We then turned our attention to the making of felt or felted cloth with a material that would not be liable to decay in water, and we found asbestos to be this desirable material.

Asbestos, (in French, Amiante) is a mineral, principally silicate of magnesia, not affected by acids nor water; fire itself has little effect on it. It is quarried in the shape of small stones, and when broken up under heavy rollers and carded, it takes the appearance of raw cotton.

This stone turns out to have been formed by nature of microscopic fibres, many times finer than silk, cotton or wool and having a much greater textile strength.

The Romans of old knew how to weave it, and used it to save the ashes of their burnt dead, as is now done in modern crematories.

The art of weaving asbestos had been lost during many centuries. It has been recovered in our own day, and the late Mr. H. W. Johns, of New York, was perhaps the very first modern manufacturer to weave asbestos cloth.

We have now a perfect felted asbestos cloth, which we use in our domestic filters, in public drinking fountains and in public water purifying plants.

Figure 1 shows one of our improved complete asbestos filtering organs. Figure 2 represents the core or inner part of the said filtering organ. The fluffy nature of the felted asbestos cloth is here very apparent, and it is easy to understand how the filtration may be rapid and perfect at the same time. The water passes from the exterior to the exterior of the asbestos felted cloth. The suspended impurities are retained on the outer surface and are easily washed off.

The space between the outer asbestos cloth seen in Figure 1, and the inner asbestos cloth of Figure 2 is filled with "Carbo-Calcis," a special charcoal which retains and oxydses the dissolved organic matter and metallic poisons, as also the bad gases. This combination is the best thing known for producing the maximum of purification with the minimum of material; every particle of it is effective.

The water may be said to be four times filtered, as it goes through four layers of purifying materials: two asbestos cloths and two layers of charcoal.

SAND.—Sand filter beds have been in use in England since 1829. Figure 3 shows a section of one of the filter beds made up of various layers of different materials on the English system.

Figure 4 shows another sand filter bed with less variety of material, according to German practice.

In all cases the finest sand is on the top, the underlying strata, made of progressively coarser material, act as support for the sand.

The voids between the grains of the sand are estimated to be about one third of the space occupied by the sand. Thus a tank capable of containing nine cubic feet of sand can also contain in the interstices thereof three cubic feet of water.

The average size of the grains of fine sand used in filter beds is about .013 inch diameter.

The voids, spaces or passages between them would therefore be about .004 inch.

The dimensions of the pathogenic microbes are:

	LENGTH. INCH.	THICKNESS. INCH.
Cholera, - -	.000118 to .000157	.000031 to .000078
Typhoid, - -	.000078 to .000118	.000012 to .000019
Diptheria, -	.000078 to .000118	.000019 to .000031

It is therefore quite natural that these micro-organisms should pass through the *ordinary* sand bed, particularly when it is quite new, or immediately after it has been cleansed.

It has been noticed that as filtration goes on through the sand beds, the filtrate becomes better and better, fewer colonies are found in it, and less species

The fine particles of clay or other earths, of vegetable and animal matters, the micro-organisms themselves, little by little, crowd the voids between the grains of sand to a depth of half an inch or more, and constitute what is now held to be the true filtering membrane or *real filter*.

In sand filtration plants comprising settling reservoirs, provision is made to send undecanted water on the freshly cleansed filter beds, so as to form in a shorter time this filtering membrane.

In other installations instructions are given to send to waste the water filtered during the first day or two, to give time for the membrane to form before the filtrate is considered fit to be sent into the drinking water mains.

All who have watched the workings of sand filters know how delicate is the so called filtering membrane formed by the mud, how unpurified water passes along the wall of sand beds and in other parts of the sand. Another weak point in sand filtration is the great quantity of sand which gets dirty and has to be taken out of the filter each time it is cleansed.

ASBESTOS FELT AS A FILTERING MEMBRANE FOR SAND FILTERS.—It has occured to us, that by depositing on the surface of the sand a layer of asbestos fibre and thus make an asbestos felt membrane, we would perfect sand filtration to a point equal to that given by our small filters, and correct the greatest defects of the English or German sand process. The asbestos fibres are extremely fine, .000015 inch, the passages therefore between them are much finer and very much more numerous than those between the particles of sand, and thus by this combination, we obtain a *better* and *faster* filtration.

Moreover, the mud being arrested by the asbestos felt membrane, the underlying sand is kept practically clean.

OUR EXPERIMENTAL PLANT IN PHILADELPHIA, Figures 5 and 6, represent the experimental plant which we have erected on our own premises, 1310 Arch Street, Philadelphia, to watch day by day, in all seasons of the year, the behaviour of the Schuylkill water under process of filtration.

Glass windows on the side of our tanks allowed us to see what takes place in the body of the filtering materials. The taps on the end of the tanks have enabled us to test the purifying action of the different layers of filtering material.

Our tests have been made not only on the color, taste and appearance of the water, but also on the speed of filtration, on the period of runs between cleansings and on numerous other points of interest. We have watched the bacteriological and chemical qualities of the filtered water in our own laboratory (Figure 7).

We have also observed the behaviour of the different kinds of sand. Figure 8 shows a section of our preferred layers. The pebbles at the bottom facilitate the drainage and flow of the filtered water, the white coating at the top represents the layer of asbestos fibre deposited on small pebbles.

Figure 9 represents ordinary layers of sand. Looked at with a magnifying glass, a great number of caverns and holes can be seen, these are caused by air.

We have introduced in our complete system remedies to this and several other minor defects which we will explain later on, and for protecting which we have applied for patents.

With our experimental plant and our series of sample taps we have demonstrated that the real work of filtration is done by the asbestos felt membrane and by the finer sand.

All the coarse material beneath which, as we have already said, acts only as support for the fine sand, is absolutely unnecessary.

We have also proved that a head of water from 9 to 12 inches gives the best results. The head of 3 to 6 feet, usually resorted to, compresses the sand too much or opens up channels, cracks or fissures.

The result of our experience is that a sand filter bed two or two and a half feet thick gives the best effluent and the greatest quantity of pure water. And thus it is that we have designed our filters with a total height of 3 feet 3 inches and a head of water of 9 inches over the sand.

It will be easily understood, that with filters 12 feet deep, the walls have to be so strong, so wide, and so heavy, that it is altogether impracticable to build them on the top of one another, and that on the contrary with our reduced depth we can adopt the modern steel, concrete

and cement mode of construction, and build two or three filter beds on the top of one another.

Thus it is that in the City of Philadelphia, if the English slow sand filters had to be erected, a vast extent of land would be required, say 160 acres.

Our asbestos felt membrane allows us to obtain a speed that is four times greater than that of the ordinary sand beds. If we establish two decks of filters this reduces the necessary quantity of land to an eighth. With three decks, a twelfth of the space is sufficient.

Thus it is that we can find on the banks, or near the present reservoirs, enough land belonging to the city to erect our filter plants.

Another advantage of our invention is that with this arrangement the second floor acts as covering for the first filter bed, the third floor for the second filter bed, and one roof does for two or three filter beds.

The troubles of open sand beds in a climate like that of Philadelphia are so great that the advantages of covered and enclosed filter beds will be fully realized.

We give herewith reduced plans of the location of our Municipal Filter Houses for Philadelphia, as also a side elevation of a three deck filter plant with our latest improvements.

CHERBOURG WATER SUPPLY.—The City of Cherbourg on the north coast of France has 42,000 inhabitants—34,000 civil and 8,000 military.

The water supply comes from a small creek "The Divette," which receives the surface water from high pastoral and cultivated slopes. At all times the water is yellow from the iron and clay soil, and in times of freshets it contains an unusual amount of yellow mud.

Typhoid fever, and all other diseases due to impure water were endemic, and the water question had been a subject of acute anxiety for years. The Army and Navy Departments had often threatened to withdraw the troops if some better water supply were not provided by the city.

A municipal commission was sent to London to study the system of water filtration applied there. The administration did not see its way clear to apply the London sand filtration process for several reasons, the principal being the necessity of building large settling reservoirs, and the space required for the filter beds themselves.

We proposed our asbestos filters, and ten public filtering fountains of our asbestos system were erected in the different parts of the city in December, 1893. These gave satisfaction to the public. Having a reservoir of 200 gallons of filtered water, and a filtering capacity of 100 gallons per hour, housewives found at all hours of the day

at the Maignen Fountains, all the water required for the family.

One year later the Municipal Council determined to apply our asbestos process to the whole water supply. Plans and estimates were submitted, and the contract was awarded us in July, 1894, for a plant capable of purifying 3,000,000 gallons of water per 24 hours. The installation was completed in September, 1895, and has been at work ever since, fulfilling in a perfect manner the conditions stipulated.

Extract of a Letter from the Mayor of Cherbourg in date of May 24th, 1896:

"The water supply of Cherbourg comes from a river which is very dirty in rainy times. The City was seeking since a long time, a practical, efficacious and relatively economical means to improve this water.

"Various systems had been examined; a Municipal Commission was sent to London to examine the sand filtration of the Thames River. Experiments (on the London plans) were made by the administration, which was then more perplexed than ever.

"Mr. Maignen came and proposed filters of his system, wherein the water passes through asbestos cloth and charcoal. Experiments made with apparatus of this nature, having given excellent results, the Municipal Council decided to supply ten districts, or wards of the City with a public filtering fountain of this system in order to complete and prolong its observations.

"After several months working of these fountains, the population showed itself quite satisfied. The Municipal administration resolved to proceed to the purification of all the water of the reservoir that supplies the City.

"A contract was made with this object with Mr. Maignen, and since the installation of these filters, before last winter, a quantity of water sufficient for the requirements of the City is served very clear by the distributing system. This quantity could be easily augmented, if necessary, by increasing the number of apparatus.

"Filtration, according to the Maignen system, asbestos cloth and Carbo-calcis, gives, I repeat, very good results. This process is assuredly one of the best that is known. It has the advantage of an economical installation; the apparatus is easily operated, and at small cost, and little space is needed.

"The water, even when the river is quite muddy, comes out limpid. In fact, the City of Cherbourg is quite satisfied with the mode of filtration which it has adopted."

The Mayor of Cherbourg,

EMM. LIAIS.

Knight of the Legion of Honor.

The Following is Extracted from Another Letter of the Mayor of Cherbourg in date of September 12th, 1898:

"The results of the Maignen System appear to us the best that could be expected of any system of filtration.

"It has the advantage of an easy and comparatively economical cleansing. It improves the water considerably and renders it perfectly clear.

"In fact it gives satisfaction to the City of Cherbourg."

The Mayor of Cherbourg,

EMM. LIAIS.

Knight of the Legion of Honor.

Figure 10 shows the Cherbourg Municipal House erected on the reservoir which supplies the city.

Figure 11 is an interior view of same.

Figure 12 represents one of the London Sand Beds in process of cleansing.

Figure 13 shows a staff of men breaking the ice surface.

VITAL STATISTICS OF CHERBOURG.

—The following is an account of the deaths that have occurred month by month, from 1894 to 1897 in Cherbourg, including the Garrison.

Years.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total.
1894, -	164	111	138	129	106	85	83	76	75	60	58	83	1168
1895, -	109	158	125	89	92	77	68	64	61	89	70	67	1069
1896, -	98	94	79	82	71	75	94	85	86	76	74	87	1001
1897, -	90	89	101	89	63	62	57	65	71	-	-	-	687 For 9 months.

The population has increased yearly, and the reduction in the general death rate is equal to 6 per cent. per 1000.

TYPHOID FEVER.

Years.	Deaths in the garrison. (Per 10,000 inhabitants.)	Deaths in the civil population. (Per 10,000 inhabitants.)
1894, - -	6.06	6.03
1895, - -	10.30	4.68
1896, - -	27.87	4.61
1897, - -	23.45	3.63

It will be observed that the rate has much increased in the garrison, whilst it has steadily diminished in the city.

The reason of this difference is not difficult to find. The garrison and a part of the city are supplied by a separate main, taking the water from the same river about two miles *above* the intake of the city. *But the water of this main is not filtered.* The supply to the city proper comes from the reservoir, on which is installed the Maignen Asbestos Filtering Plant.

Some other diseases show a considerable reduction.

AVERAGE CASES OF THE YEARS.

	1894, '95, '96.	1897.
Measles and Complications, Scarlatina,	55.3	5
Diphtheria and Croup, - - -	14.6	3
Pneumonia, - - - - -	67.3	34
Diarrhœa, Dysentery, - - -	71.6	48

These figures were not needed to prove that death and disease could be diminished by filtration, but they show that the Maignen Asbestos system has had there a good practical trial.

It might be asked if the Maignen mode of filtration is such a success in Cherbourg, why not propose it for the city of Philadelphia. To this we have to reply:

1st. Cherbourg is a small city, and really never uses more than about two million gallons of water daily.

2d. The difference of level between the filter and the level of the water in the reservoirs below is never less than 15 feet, and sometimes it is 18 or 20 feet.

3d. If we had to use asbestos *cloth* and charcoal for the 300,000,000 gallons of water needed in Philadelphia, the cost would be very considerable.

CONCLUSIONS CONCERNING CHERBOURG. —One of the causes of our success in Cherbourg is the use of an asbestos cloth stretched over the layer of charcoal.

We obtain a better result with one of our latest improvements, which consists in making the asbestos felt membrane with asbestos fibre *on the sand layer*, as already described. *It is much cheaper and more easily handled.*

PARIS EXPERIMENTAL PLANT.—Paris has a double set of mains; one giving spring water sold by the city at about 24 cents a thousand gallons for drinking purposes; the other distributing ordinary river water for flushing the sewers, watering the streets and gardens, for fire hydrants and industrial purposes, at 12 cents a thousand gallons.

In dry years, the springs do not give all the water that is needed, and recourse must be had to the use of unfiltered Seine water for drinking purposes.

On the assumption that the residents in the rich quarters are in the country in summer, or can afford to buy mineral waters or filters, the disease bearing river water has been distributed alternately among the better wards, the short supply of spring water being reserved for the poorer districts.

In 1894 and '95 a public competition was held by the Municipality of Paris for "the purification and sterilization of river water." 148 inventors sent in papers, 102 were eliminated at the first examination, 42 were considered on a second reading, 19 were admitted to a practical trial.

The report of the trial commissioners concluded in favor of *sand* and *asbestos* filtration.

The city had already erected four large sand beds with continuous decantation tanks as seen in Fig. 14. Our asbestos filters having in the trials given the best practical results, we were allowed to erect a large filter plant on the ground of the city, and close to the sand beds. A little corner of our plant is seen on the right of Figure 14. Figure 15 shows the same seen from the plain below; the tanks in front are our primary filters, the flat surface which is seen behind is the roof of the secondary filters.

Figure 16 is one of the four filter chambers composing our Paris experimental plant. The filtering elements are asbestos cloth sacks containing, as explained already, charcoal and asbestos cloth core. The attendant is washing off the outer surface of the filtering organs.

We have watched daily for a whole year the working of the two systems: plain sand beds and our asbestos system, and we have come to the conclusion that *by forming our asbestos felt membrane over the sand beds, and correcting the numerous defects which we found in the sand system, we would obtain the best practical and most economical results in dealing with very large supplies of water.* That is why we propose for the city of Philadelphia our **Improved Natural Sand Filtration.**

Figure 1. One of Maignen's Filtering Organs complete, as now supplied to the United States War Department, Washington.

Figure 2. The Core of one of Maignen's Filtering Organs, Showing the Asbestos Felted Cloth.

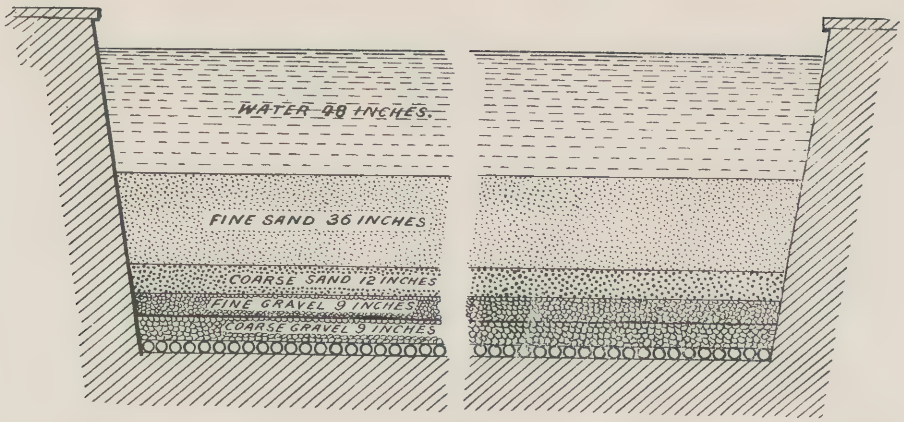


Figure 3. Section of an English Filter Bed.

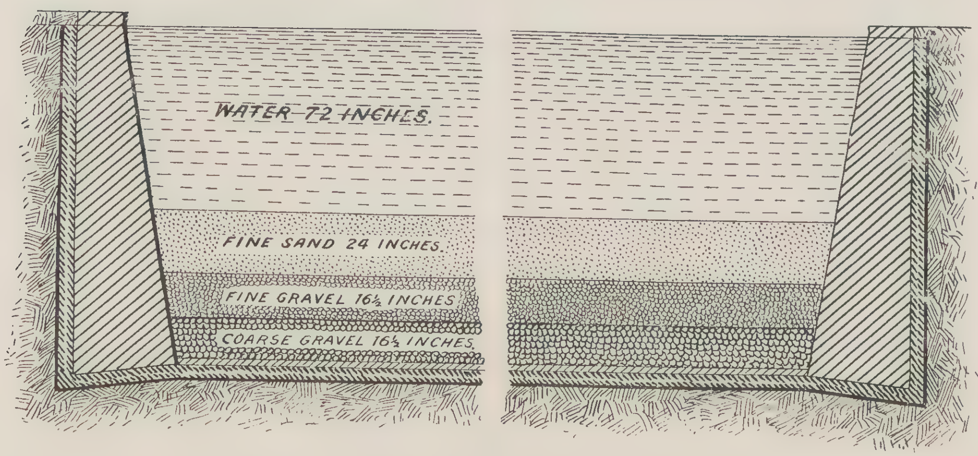


Figure 4. Section of a Berlin Filter Bed.

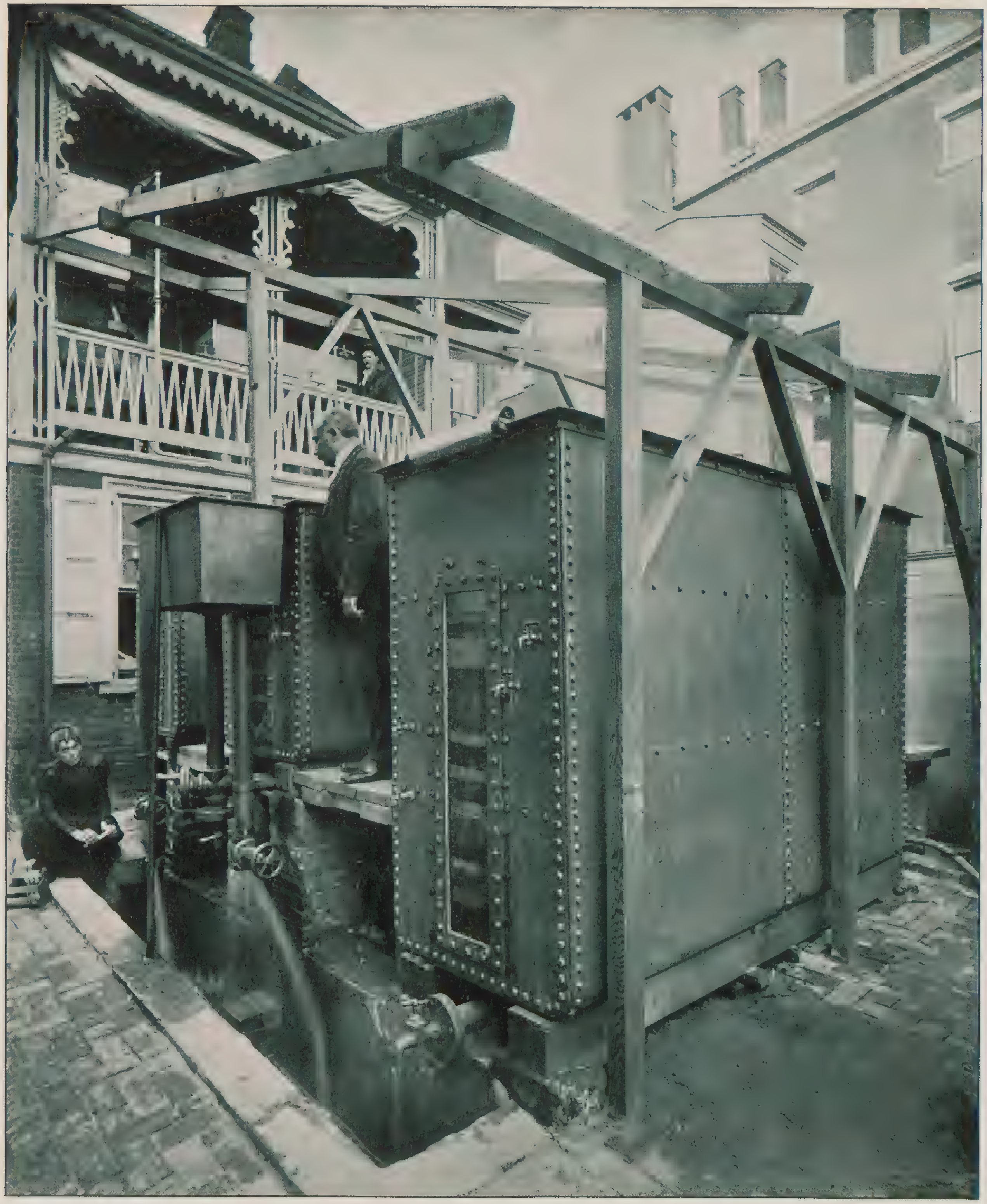


Figure 5. Maignen's Improved Sand Filtration Experimental Plant.

1310 Arch St., Philadelphia.

Figure 6. Maignen's Improved Sand Filtration Experimental Plant.

1310 Arch St., Philadelphia.

Figure 7. Mr. Maignen's Bacteriaological Laboratory.
Dr. Mary E. Gillespie, Director.

Figure 8. Maignen's Asbestos Felt Membrane on Sand Bed.

Figure 9. Caverns and Holes in Ordinary Sand Beds.

Figure 10. Cherbourg Municipal Filter House, erected on City Reservoir.

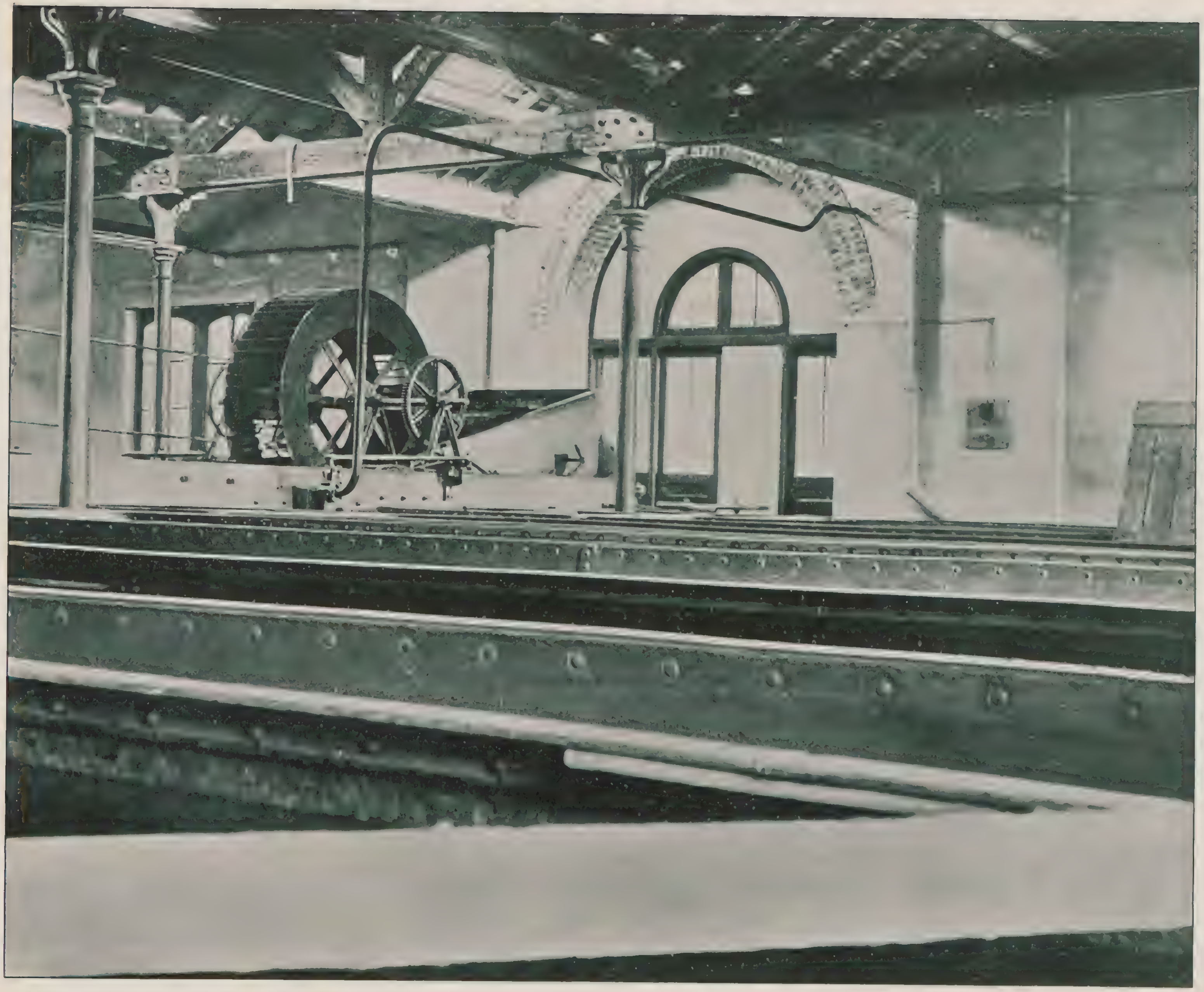


Figure 11. Interior of Cherbourg Municipal Filter House.

Figure 12. London Filter Bed under process of cleansing.
From Mr. W. P. Mason's "Water Supply."

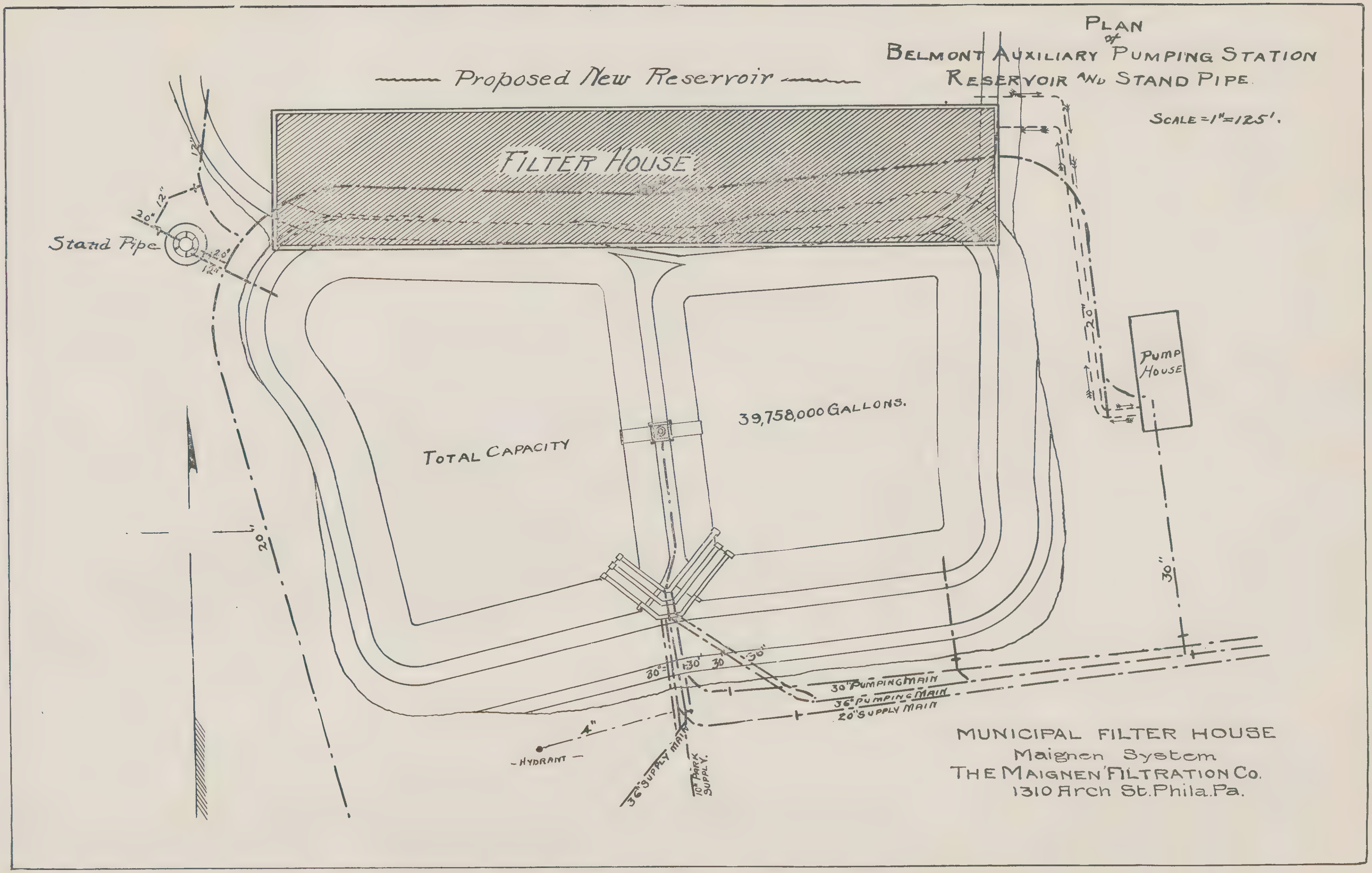
Figure 13. Breaking the Ice on a London Filter Bed.

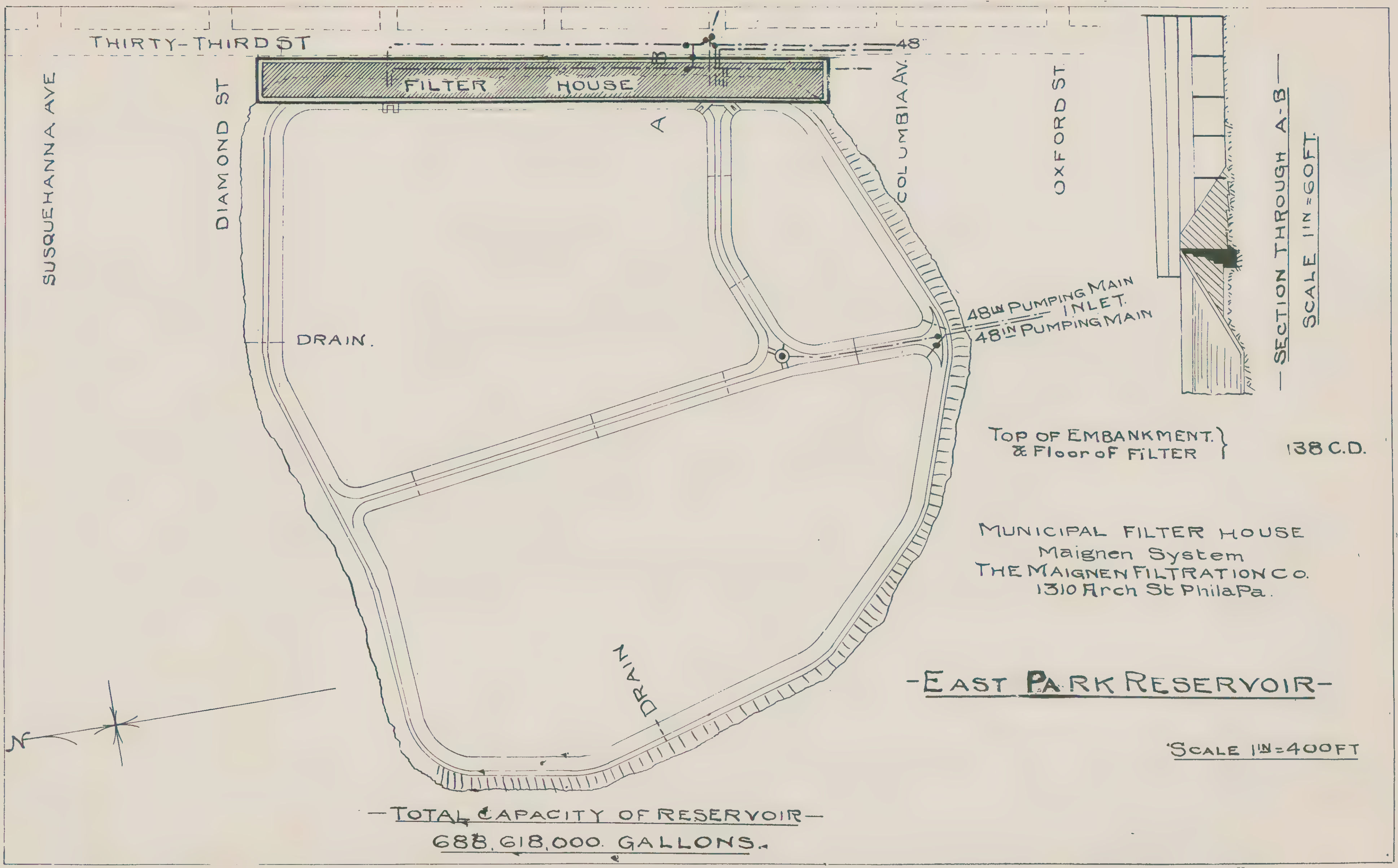
From Mr. W. P. Mason's "Water Supply."

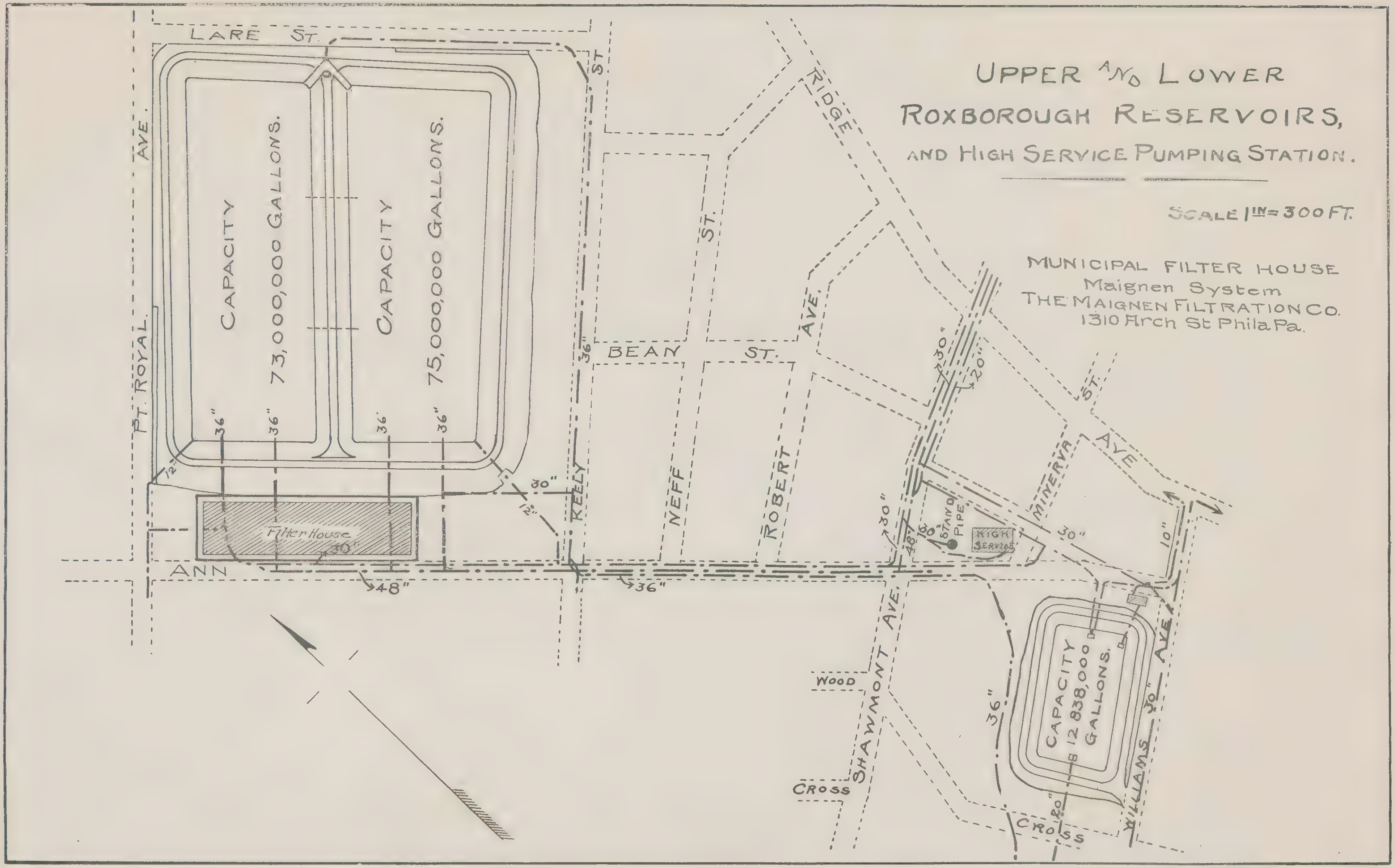
Figure 14. The City of Paris Experimentation Filter Station, at St. Maur, France.

Figure 15. Maignen's Paris Experimental Plant. The tanks in front represent the primary filters.

Figure 16. Maignen's Paris Experimental Plant. Washing the filter surface.


PLAN of BELMONT AUXILIARY PUMPING STATION RESERVOIR AND STAND PIPE
SCALE = 1" = 125'.
Proposed New Reservoir
FILTER HOUSE
Stand Pipe
PUMP HOUSE
TOTAL CAPACITY
39,758,000 GALLONS.
30" PUMPING MAIN
36" PUMPING MAIN
20" SUPPLY MAIN
36" SUPPLY MAIN
10" PARK SUPPLY
HYDRANT
MUNICIPAL FILTER HOUSE
Maignen System
THE MAIGNEN FILTRATION Co.
1310 Arch St. Phila. Pa.

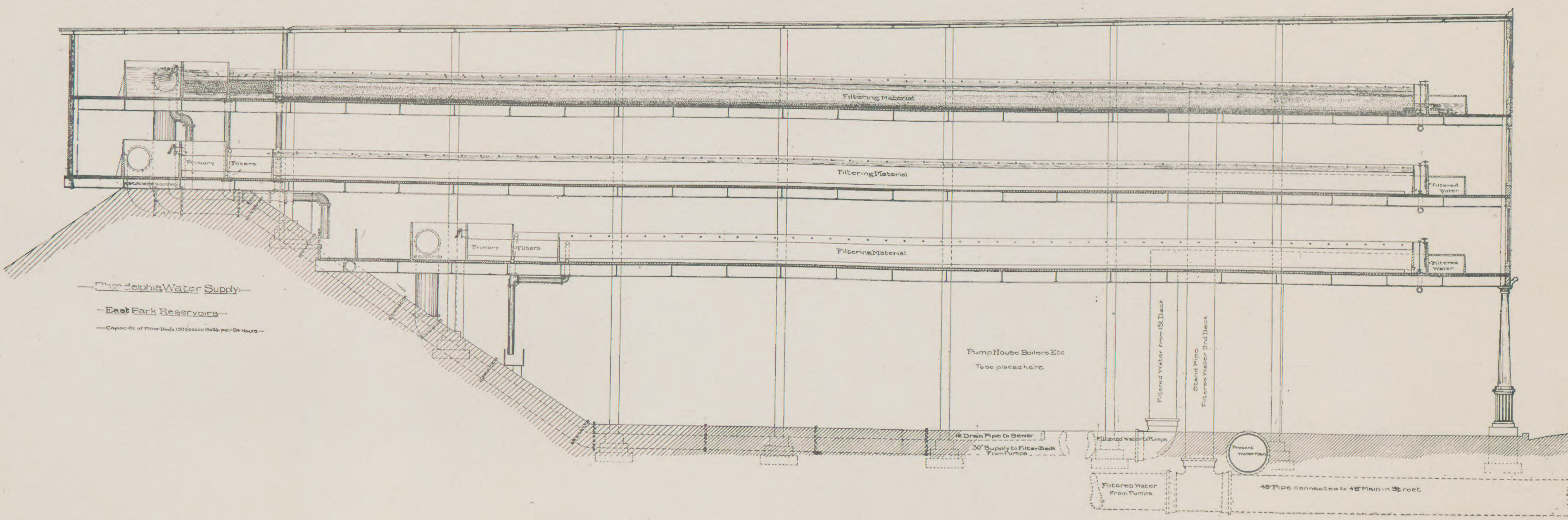

THIRTY-THIRD ST
SUSQUEHANNA AVE
DIAMOND ST
FILTER HOUSE
COLUMBIA AV.
OXFORD ST.
48
A
B
DRAIN.
48IN PUMPING MAIN
INLET.
48IN PUMPING MAIN
SECTION THROUGH A-B
SCALE 1IN=60FT.
TOP OF EMBANKMENT. & Floor of FILTER
138 C.D.
MUNICIPAL FILTER HOUSE
Maignen System
THE MAIGNEN FILTRATION Co.
1310 Arch St Phila Pa.
-EAST PARK RESERVOIR-
SCALE 1IN=400FT
DRAIN
N
-TOTAL CAPACITY OF RESERVOIR-
688,618,000 GALLONS.

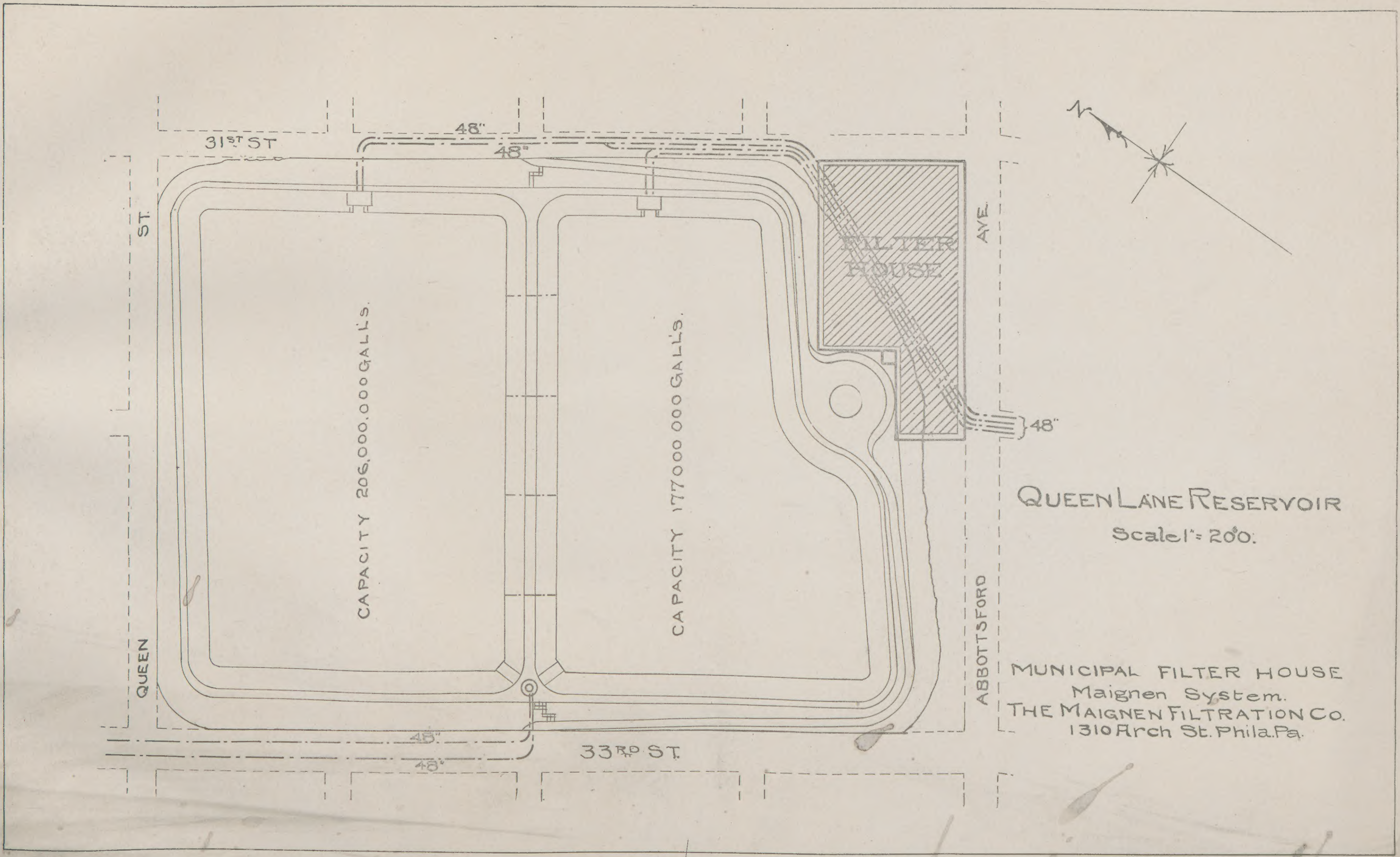

UPPER AND LOWER
ROXBOROUGH RESERVOIRS,
AND HIGH SERVICE PUMPING STATION.
SCALE 1IN = 300 FT.
MUNICIPAL FILTER HOUSE
Maignen System
THE MAIGNEN FILTRATION CO.
1310 Arch St Phila Pa.
LARE ST.
PT. ROYAL AVE.
CAPACITY 73,000,000 GALLONS.
CAPACITY 75,000,000 GALLONS.
Filter House
KEELY ST
BEAN ST.
NEFF ST.
ROBERT AVE.
RIDGE AVE.
MINERVA ST.
ANN
SHAWMONT AVE.
WOOD
CROSS
STAND PIPE
HIGH SERVICE
CAPACITY 12,838,000 GALLONS.
WILLIAMS AVE
36"
30"
48"
20"
12"
10"

MUNICIPAL FILTER HOUSE

Maignen System

Scale 1/4 inch-1foot Phila.Pa.




31ST ST
48"
48"
QUEEN ST.
CAPACITY 206,000,000 GALL'S.
CAPACITY 177000 000 GALL'S.
FILTER HOUSE
48"
ABBOTTSFORD AVE.
48"
48"
33RD ST.
QUEEN LANE RESERVOIR
Scale 1" = 200'.
MUNICIPAL FILTER HOUSE
Maignen System.
THE MAIGNEN FILTRATION Co.
1310 Arch St. Phila. Pa.